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Harrison

Inventor: Sines
Serial No. 09/364,256

PATENT APPLICATION
Navy Case No. 79,955

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: E. Sines

Serial No. 09/364,256 Examiner: G. Perez

Filed: July 30, 1999 Group Art Unit: 2834

For: ELECTRICAL POWER
COOLING TECHNIQUE

AMENDMENT AFTER FINAL REJECTION

Associate Commissioner for Patents
Washington, DC 20231

Sir:

This is in response to an Examiner's Office Action of October 26, 2000. It is respectfully requested that the following amendment be entered into the record.

IN THE CLAIMS:

Revised version of Claim 14

NE 14. (Thrice Amended) A method for cooling electrical devices having layers of electrically conductive material wound on a core

comprised of the following steps:

placing a non-metallic thermally conductive strip having a first and second end, capable of conducting heat from between preselected layers of the electrically conductive material, said strip extending through the layers of electrically conductive material wound on the core and said first and second end on the non-metallic thermally conductive material extending outside of the area covered by the electrically conductive material; and

conducting the heat from the first and second ends of the non-metallic thermally conductive material.

Clean version of amended Claim 14

14. (Thrice Amended) A method for cooling electrical devices having layers of electrically conductive material wound on a core comprised of the following steps:

placing a non-metallic thermally conductive strip having a first and second end, capable of conducting heat from between preselected layers of the electrically conductive material, said strip extending through the layers of electrically conductive material wound on the core and said first and second end on the non-metallic thermally conductive material extending outside of the area covered by the electrically conductive material; and

conducting the heat from the first and second ends of the non-metallic thermally conductive material.

Revised version of Claim 15.

15. (Thrice Amended) A method, as in Claim 14, further comprising the steps of:

placing a thermally conductive strip having a first and second end between a plurality of predetermined laminations of the core, said first and second ends of the thermally conductive strip extending outside the core.

Clean copy of revised Claim 15

15. (Thrice Amended) A method, as in Claim 14, further comprising the steps of:

placing a thermally conductive strip having a first and second end between a plurality of predetermined laminations of the core, said first and second ends of the thermally conductive strip extending outside the core.

RESPONSE

Claims 13-17 remain in the application.

Claims 13 - 17 have been finally rejected by the Examiner.

REJECTION UNDER 35 USC § 112, SECOND PARAGRAPH

The Examiner has rejected Claim 15 under 35 USC § 112, second paragraph, as being indefinite in that it fails because the limitation "predetermined laminations" in line 4 lacks an antecedent basis.

Claim 15 has been revised to correct this lack of antecedent basis for "predetermined laminations" in line 4.

Therefore, it is respectfully submitted that Claim 4 is now allowable in that the objected to language has been removed.

REJECTION OF CLAIM 14 UNDER 35 USC § 102(b)

The Examiner has rejected Claim 14 as being anticipated by *Kanai* in that *Kanai* discloses a method for cooling electrical devices having layers of electrically conductive material wound on a core comprising: (a) placing a thermally conductive strip capable of conducting heat, and (b) conducting heat from the first and second ends of the thermally conductive material.

The *Kanai* patent provides a reduced thermal grade in the field windings to make a lightweight, compact salient-pole rotary field synchronous motor. *Kanai* tried to solve the problem of heat by inserting heat dissipation plates into the windings which protruded out of the windings where forced air is used to cool

them. The dissipation plates provide an increased radiation surface to the salient-pole rotor motor windings.

Kanai describes the installation of heat dissipation plates which are in the form of fins that are placed among the conductors to provide paths for heat to conduct to the dissipation plates which protrude out of the field windings. On Page 4 of the English translation of the patent, *Kanai* identifies the material of the dissipation plates as "aluminum", known to be a metal and easily conduct electricity. This differs materially from the Applicant's application in that the claimed device utilizes an insulator to conduct the heat out of the motor and not a metal.

The *Kanai* patent primary means of heat removal is through radiation and forced air. The heat dissipation plates can further be modified with slots to hold the field windings when they become long. *Kanai* fails to clearly understand that adding a metal into the coil windings of the stator motor causes problems due to eddy currents being induced into this metal and their affecting the performance of the stator motor.

Kanai used a metal comprised of aluminum, and this metal is subjected to changing magnetic fields in the stator windings and will produce eddy current losses in the form of heat, which only adds to the heat loss of the stator motor, or at the very least reduces the effectiveness of the dissipation plates. The claimed

application claims an insulator with superior thermal conductivity, not a metal and therefore this material does not produce large quantities of eddy currents when directly exposed to or subjected to high density changing magnetic fields. This is a critical ans material difference between the prior art and the claimed invention.

Kanai teaches the use of a metal to remove heat from the surface of the coil windings. These dissipation plates are in close proximity to the changing magnetic fields of the motor and therefore will produce eddy current losses in the form of heat and adding to the motor losses. This is not the case in the Applicants claimed device. In addition, the eddy currents will effect the magnetic structure by producing counter magnetic forces which will redirect some of the magnetic lines of force causing increased inductance losses due to stray magnetic fields not being tightly linked to the coils and stator pole. The Applicants claimed invention uses a material known as K1100 that does not have as much effect as a metal (~ 35X's less when compared to aluminum) and therefore would produce less stray magnetic losses in the motor. This is a very important difference when the goal is lighter, smaller motors.

The material utilized by the applicant in the claimed device is very light and can be attached to the windings through simple adhesive action during the construction of the transformer or

motor sealing. The risk of coming apart due to centrifugal force is very small due to the low specific weight of the carbon material, typically 10's of grams per coil.

As stated above, eddy-current losses, in the form of heat, are ~35X's more for aluminum than the K1100 while exposed to the same magnetic fields. This is because aluminum is a much better conductor of electricity than the high modulus carbon fiber known as K1100. This is a major difference between the Applicants claimed invention for motor/generators and the *Kanai* patent.

The Applicants claimed invention provides a unique thermal interface solution that is superior over *Kanai* and is not technically flawed due to excessive eddy current losses in the material used to conduct heat and adding to the motor heat load. By using a high modulus carbon fiber, a direct thermal path is provided from the interior of the motor windings to the outside motor casing, providing a cooling path to the windings directly, free of additional eddy current heat losses. This minimizes the migration of heat into the motor laminations and allows for an increase in current density, reduces total system weight, reduces volume and improves system reliability.

However, Claim 14 has been amended to specifically state that the thermal conducting material is non-metallic, not metallic as taught by the prior art. Hence it id respectfully submitted that Claim 15 is now allowable.

REJECTION OF CLAIM 15 UNDER 35 USC § 103(a)

The Examiner has rejected Claim 15 under 35 USC § 103(a) as being unpatentable over *Kanai* in view of *Herron*.

The examiner states *Kanai* discloses a method for cooling electrical devices but *Herron* places a thermal conductive strip, therefore it would have been obvious to modify *Kanai*.

The forgoing discussion as to the rejection of Claim 14 under 35b USC § 102(b) is equally applicable here and is therefore incorporated in total by reference.

Herron teaches the design and fabrication of a motor using standard materials and a non-magnetic lamina said to be aluminum. Paragraph 1, section 25-35 applies. *Herron* teaches that these non-magnetic laminas can be stamped and formed by metal stamping techniques and are preferably made from aluminum or brass. Paragraph3, section 15-20 applies. These stampings are designed with voids and chambers for transverse cooling air to be forced through them, Column 3, Lines 35-45. Also, note, that in the title of the invention, *Herron* indicates that the non-magnetic laminations are for structural support, with only secondary use as a heat-removing device.

Herron places non-magnetic laminas into the design structure to provide mounting points for the permanent magnetics and to provide the necessary working air gaps as well as producing a low

reluctance flux path for the motor to operate in. These non-magnetic laminas are also designed to aid in cooling the motor assembly by adding void and chambers, but this is not the primary function. See Column 1, Lines 35-45.

Herron states in Claim 2 that these non-magnetic laminas are used to form cooling fins. The concept of using any metal in this area is technically incorrect due to the changing magnetic fields the non-magnetic laminations said to aluminum or brass would be subjected to in the motor. Aluminum and brass are both good conductors of electricity and when subjected to changing magnetic fields they produce eddy currents that react as previously stated. *Herron* also relies on forced air for cooling the internal structure and designs the cooling paths directly into the motor to facilitate the flow of air. The *Herron* motor is simply a complex air-cooled motor due to the air passage ways integrated into the internal mechanical structure of the motor.

The claimed invention of the applicant is not in conflict with the *Herron* patent because the claimed device uses a completely different scientific method of removing heat from the internal structure of an electrical motor. *Herron* describes the cooling fins as non-magnetic laminas, not as "thermally conductive disks" and/or "thermally conductive strips." At no time has *Herron* taught such disks or strips, *Herron* relies on metal to conduct the heat out of the motor or to the fin tips and

then to the ambient air. The applicants claimed device relies on an insulator made from carbon to conduct heat out of the motor to the ambient, this is a major structural difference.

Further, Claim 15 is a dependent claim of the independent claim 14, placing further limitations on Claim 14. Therefore, it is respectfully submitted, if Claim 14 is allowable, Claim 15 as an dependent claim of Claim 14 is also allowable.

REJECTION OF CLAIM 16 UNDER 35 USC § 103(a)

The Examiner has rejected Claim 16 under 35 USC § 103(a) as being unpatentable over *Kanai* in view of *Davis*.

The Examiner states that *Kanai* discloses a method for cooling an electrical device and *Davis* discloses the placing of one or more non-metallic, flat, thermally conductive strips for the purpose of improving thermal conductivity in the coils. Therefore ir would have been obvious to modify *Kanai* with *Davis*.

The foregoing discussion of *Kanai* is applicable t this point therefore, all previous comments on *Kanai* are hereby incorporated in total by reference.

Davis teaches the application of capacitive voltage distribution methods in order to reduce the damage to the motor windings due to high speed voltage transients related to the voltage wave forms used to control reluctance motors during

switching. *Davis* had discovered determined by experience that shorting occurs in the first few turns of the motor windings due to insulation breakdown from high-speed voltage transients that fatigue the insulation. The heat developed results in insulation break down. Column 2, Lines 10.

Davis teaches a method of controlling the windings failure problem in switched reluctance motors systems. Column 2, Lines 32-38. *Davis* further teaches the construction of this internal distributed windings capacitor and how he integrates this into each phase of the reluctance motor windings. The primary goal of *Davis* is to distribute the voltage stress from switching over more windings and to reduce the voltage peaks of the transient voltage spikes in order to protect the windings insulation. *Davis* teaches both strips and helically wound configurations to implement these distributed windings capacitors. Column 3, Lines 47-50.

Davis teaches that there is no real need for a particular composition of insulating sheet or material, but the material should be relatively thin with high dielectric strength and good thermal conductivity. Paragraph 7, section 20-25. *Davis* recommends the use of an aramid paper, such as NOMEX, as a suitable construction material because it is light weight, very strong heat-resistant synthetic material and comes in sheet form. *Davis* sandwiches this between two layers of windings, at the

start of the windings to distribute the voltage stress of the switching waveform. Between this insulating material, *Davis* adds electrical conductors like aluminum, copper, conductive plastics, graphite conductive mats for the purpose of building a capacitive voltage distributor. Column 7, Lines 40-55.

Davis had no intentions, nor did it teach, the use of the capacitive voltage distributors as a new method of heat transfer or a new method to cool the windings. In *Davis* the main teaching is to keep the windings from failing due to voltage dielectric breakdown. The is no conflict between the Applicant's claimed invention and *Davis* in the application to motors. The Applicant's claimed invention is a completely different application directed at cooling the motor windings and the laminations through heat removal by conduction and convection with the use of a carbon material.

Davis is not concerned with thermal conductivity of the windings or the ferromagnetic laminations to the operating temperature of the working device, this is a major structural and theoretical difference between *Davis* and the Applicant's claimed invention. The Applicant's claimed invention having as its primary goal the increase of power density by reducing the thermal resistance of the coil windings and motor laminations. t no time in *Davis* is the thermal conductivity of the materials described or the reduction of the devices operating temperature.

Davis, indeed, tends to teach away from the Applicant's claimed device.

The Examiner, on page 4, paragraph 3, refers to *Davis* as placing one or more non-metallic (Column 2, Lines 23-31), flat, thermally conductive strips, for the purpose of improving thermal conductivity in coils. The Applicant respectfully submits that the Examiner erred in the determination of the purpose of these elements. This reference would more properly be placed in a discussion of *Glass* in the following section.

Therefore, it is respectfully submitted that *Davis* and the Applicant's claimed invention as set forth in Claim 16 are materially differ and Claim 16 is allowable in view of the foregoing discussion. In the magnetic core patent of *Davis*, there is no teaching as to the reduction of mass or size of the magnetic's due to and increase in current density or a reduction ov operating temperature, *Davis*, however does teach the reduction of mass due to the interleaving of non-magnetic material between the laminations while maintaining a valid magnetic circuit, thereby lowering the weight of the circuit.

REJECTION OF CLAIMS 13 AND 17 UNDER 35 USC § 103(a)

The Examiner has rejected Claims 13 and 17 under 35 USC § `103(a) as being unpatentable over *Herron* in view of *Glass* and

further in view of *Kanai* and *Jarczynski*.

The foregoing discussions as to *Herron* and *Kanai* are pertinent to the discussion of this basis of rejection and are therefore hereby incorporated by reference in total at this point.

The Examiner states that *Herron* discloses an electric motor with laminations, thermally conductive disks; *Glass* discloses circular non-metallic, flat, thermally conductive disks between preselected layers of laminations; *Kanai* discloses an electrically conductive material wound in layers within the laminations with thermally conductive strips placed between pre-selected layers; and *Jarczynski* discloses a means for conducting heat at the end of the conductive disk and strips for the purpose of removing heat.

Glass is mainly teaches the application of magnets to the neck of a cathode ray tube used in television sets to focus the electron beam on the face of a TV screen. In addition, *Glass* also suggests that the invention could be applied to motors to reduce the total weight by adding addition air gaps between the laminations.

One of the main teachings of *Glass* is to reduce the quantity of the magnetics material used in each application. A non-magnetic material is interleaved into and between the ferromagnetic laminations and is said to be a non-magnetic sheet

with fibers or the like of, type of material is not taught in *Glass*, with no comment as to the thermal conductivity or the need to reduce the thermal resistance of the magnetic assembly.

Glass has no teaching as to the application of thermally conductive cooling strips to improve the operations of the magnetic structure. Similarly, it is respectfully submitted that the use of non-metallic, flat, thermally conductive disks for the purpose of improving the cooling performance of the stator structure, as cited by the Examiner on page 5, paragraph 4, is incorrect. Applicant upon review of the *Glass* patent cannot find no evidence to confirm the Examiner's basis of rejection.

Further, there is no showing of any teaching that would motivate a person skilled in the art to combine the teachings of *Herron; Glass, Kanai* and *Jarczynski* to duplicate the Applicant's claimed invention.

As noted in prior papers, the purpose of *Jarczynski* is to utilize cooling passages designed into the outer motor casing where chilled water could be pumped through to remove heat from radial non-magnetic thermal conductance paths. *Jarczynski* provides preferential solid paths of thermally conductive laminations made of non-magnetic thermal conductor said to be copper. *Jarczynski* teaches the use of non-magnetic thermal conductors, such as copper which is a metal and a good conductor of electricity and therefore subjected to eddy currents when

placed in a changing magnetic field as one would find within the motor laminations. In addition, copper has a positive temperature coefficient and its resistivity increases with temperature rise due to an increase in Rho, ρ.

The *Jarczynski* patent requires additional overhead for this technical approach to be completely effective ans not shown on such patent. The inventor fails to discuss that most of the heat losses in the generator windings is from the I^2R power losses in the generator/motor windings and not the power losses in the motor laminations. The preferential thermally conductive laminations made of copper are placed in direct contact with the high density, high frequency magnetic fields. Power losses from eddy-current losses, in the form of heat are ~70X more because copper is a better conductor of electricity than high modulus carbon fiber in the same magnetic fields. This is a material difference between the Applicant's claimed invention and *Jarcynski*.

The Applicant's claimed invention provides a unique thermal interface solution that is superior to *Jarczynski* and is not technically flawed due to excessive eddy-current losses in the materials and adding to the motor heat load. By using a high modulus carbon fiber a direct thermal path is provided from the interior of the motor windings to the outside motor casing, thereby providing a cooling path to the windings directly. This

minimizes the migration of heat into the motor laminations, allows for an increase in current density, reduces total system weight, reduces volume and improves system reliability. *Jarczynski* merely conducts the heat off the outside of the windings unlike the high modulus carbon thermal interface which goes directly into the interior of the motor windings.

Therefore, it is respectfully submitted that neither the *Herron, Glass, Kanai* nor *Jarczynski* patent, individually or in combination, teach the Applicant's claimed invention because none of this prior art withdraws heat directly from the interior of the motor windings thereby allowing the motors to run more efficiently because the motor windings will remain cooler due to the direct thermal path to te ambient atmosphere provided by the high modulus carbon thermal conductor where the interior heat is dissipated through either radiation or forced air.

PRIOR ART MADE OF RECORD

The prior art made of record and not relied upon by the Examiner has been reviewed by the Applicant and found not to be pertinent art.

TRAVERSAL OF FINALITY OF ACTION

Applicant traverses the Examiner's making this paper a final action because effectively the prior basis of rejection by the Examiner rendered all such prior argument by the Applicant moot because of new grounds of rejection. Therefore Applicant's respectfully request such determination of finality be withdrawn.

It is therefore requested, based on the new grounds for rejection, that the declaration by C. Moss be entered into the record.

ENGLISH TRANSLATION OF PRIOR ART

A copy of the English translation of the Japanese patent are attached to this paper for the Examiner's edification and use.

CONCLUSIONS

It is respectfully submitted that all basis for rejection by the Examiner have been overcome and claims 13 -17 are now allowable. Therefore, it is respectfully requested that Claims 13-17 be allowed and passed to issue at the earliest possible

time.

Respectfully submitted,

John J. Karaek
Reg No. 36,182
Associate Counsel (Patents)

Reg No. 34,935

Prepared by:
Charles J. Stockstill
Reg. No. 34,935
(202) 404-1553
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